SCIENCE ABSTRACTS.

Section A.—PHYSICS.

NOVEMBER 1918.

GENERAL PHYSICS.

1138. *Stresses in Curved Beams.* **J. J. Guest.** (Roy. Soc., Proc. 94. pp. 1-21, Sept. 2, 1918.)—An investigation of the stresses produced in a curved beam of uniform section when subjected to a bending moment. If r_1 and r_2 are the inner and outer radii of curvature of the beam, the equation for the max. stress is—

$$p_{\text{max.}} = (4M/ah^3)\left\{(1-n)^2(1-n^2+2\log n)\right\}\left\{(1-n^2)^2-4n^2(\log n)^2\right\}^{-1},$$

where $n = r_1/r_2$ and $h = r_1 - r_2$ (the depth of the beam). Curves and tables are given in the paper for the determination of the values of the stresses for beams of certain cross-sections, and in the case of other sections, provided that they have no extraordinary features, a consideration of the results obtained shows that the shearing stress about the circumferential lines produces small effect upon the circumferential stresses, and in such cases the method of estimation given affords a close approximation to the max. stress produced by the bending moment. J. W. T. W.

1139. *Stability of a Parachute.* **S. Brodetsky.** (Tôhoku Math. J. 14. pp. 116-128, Aug., 1918.)—Investigates the equations of motion of a falling parachute with its load, assuming these to be rigidly connected and not to possess independent oscillations. The conditions for stability are that $A^2 > B$, and D, the depth of the centre of gravity of the passenger below the centre of gravity of the parachute itself, must lie between the values—

$$\tfrac{1}{2}(1-m)^{-1}\left\{A \pm \sqrt{A^2-B}\right\}.$$

$$\text{Here } A \equiv a/\rho \text{ and } B \equiv 4\left\{(1-m)/m\right\}\left\{(1-m)k_1^2 + mk_2^2 - Ad_1\right\};$$

$m = W_2/(W_1 + W_2)$, where W_1 is the weight of the umbrella, and W_2 that of the passenger; $W_1k_1^2$ and $W_2k_2^2$ are respectively the moments of inertia of the umbrella and the passenger about parallel axes through their respective centres of gravity and parallel to the plane of the umbrella, a is the radius of the umbrella and ρ is a constant depending on its shape (for a circular plate ρ is probably nearly equal to 4). J. W. T. W.

1140. *Forced Vibrations experimentally Illustrated.* **E. H. Barton** and **H. M. Browning.** (Phil. Mag. 36. pp. 169–178, Aug., 1918.)—It is well known that forced vibrations play an important part in most branches of physics. In this connection may be mentioned resonance tubes, fluorescence, Lodge's syntonic jars, Hertz's oscillator and resonator, wireless telegraphy, and possibly it is justifiable to add the sensitive parts of ear and eye. It accordingly seems desirable to have some quite simple vivid mechanical illustration that exhibits qualitatively and quantitatively the chief phenomena concerned. Types of such experiments are here described.

The apparatus consists of a single heavy driving pendulum and a number of light driven ones, of graduated lengths and all suspended from the same tightly stretched cord. Thus the various effects of tuning and mistuning may be observed simultaneously. By a steady direct view the variation of amplitude with tuning is seen in spite of the phase-differences involved. By a stroboscopic view (or illumination) the variation of phase with tuning may be exhibited to a small class or a larger audience.

The above remarks refer generally to the experiment in various forms. For confirmation of exact quantitative relations the experiment needs arranging with special attention to certain details which may be readily secured. It is then found to confirm the theory in every respect. By changing to responding bobs of greater density, and therefore smaller damping, the consequent increased sharpness of resonance is shown. In the paper the mathematical theory is developed; also photographic reproductions are given showing four time-exposures and eight instantaneous views of the responding pendulums (which have bobs of paper in the form of cones).

E. H. B.

1141. *Electronic Frequency and Atomic Number.* **P. D. Foote.** (Phys. Rev. 12. pp. 115–121, Aug., 1918.)—The empirical relation proposed by H. S. Allen [see Abs. 226, 228 (1918)] connecting atomic numbers, fundamental frequencies, fundamental numerals and ionisation potentials, does not, in the opinion of the author, appear accurately to interpret recent experimental data. The apparent agreement obtained between observed ionisation potentials and those computed on the basis of Allen's theory is due to the fact, the possibility of which was suggested by Allen, that we are concerned mainly with large numbers, and that sufficiently accurate data are lacking for the three or four elements which would give small enough numbers to afford a criterion of the theory. From an empirical standpoint the theory does not appear to be justified, because a wide range of numbers may be chosen for the fundamental frequency with equally satisfactory results. Also, Allen's theory may be apparently evolved equally well from experimental data arranged properly, or from the same numerical data arranged by chance with no reference to their physical significance. The theory fails in determining the limiting frequencies ($\nu = 1{\cdot}5\,S$) of the elements for which these values are accurately known. We might expect the theory to be of value in predicting results which could be more accurately confirmed. Such is not the case, however. For example, the ionisation potential of sodium (or any other material) cannot be predicted by this theory, because the theory requires a knowledge of the integral multiplier for the ionisation potential of sodium, which in turn requires a knowledge of the ionisation potential for its determination. The integral multipliers for the same element are different for different phenomena, and no relation is apparent between the integers determined by different phenomena.

A. B. W.

1142. *On the Connection between the Atomic Weights of the Chemical Elements, the Densities and the Thermal Properties.* **K. Fehrle.** (Phys. Zeits. 19. pp. 281–288, July 1, 1918.)—The object of the present paper is to present in mathematical form the relationship between the atomic weights of chemical elements and their properties in the light of current theories which picture molecules as being constructed of the same fundamental components. The latter are simply termed atoms; the molecule is regarded as a sphere containing these atoms distributed in homogeneous manner and rotating with common angular velocity w about the same middle point. The additional assumption is made that the energy of a molecule of radius R is given by $U = CNw^2R^2$, and the mass by $m = KNw$, where N denotes the number of atoms in the molecule. It is shown that the thermal change W produced by the union of two elements of molecular weights A_1 and A_2 and densities s_1 and s_2, is connected with the molecular weight A_3 and density s_3 of the compound formed by the equation—

$$W = \frac{1 \cdot 584}{z}\left[xA_1\left\{\sqrt[3]{(1/s_1^2)} - \sqrt[3]{(1/s_3^2)}\sqrt{(A_3/A_1)}\right\} + yA_2\left\{\sqrt[3]{(1/s_2^2)} - \sqrt[3]{(1/s_3^2)}\sqrt{(A_3/A_2)}\right\}\right] \text{ kg. cals.},$$

where x mols. of the first element unite with y mols. of the second element to form z mols. of the compound. By molecular weight is understood that weight which the molecule actually possesses during the reaction. For metallic compounds the result is given by the usual molecular weight divided by the sum w of the valencies of the elements. The formula then gives the thermal radiation for $1/w$ mol. A table of data is given for a large number of compounds.
H. H. Ho.

1143. *The Exact Values of "g" through the United States.* **S. A. Moss.** (Gen. El. Rev. 21. pp. 344–352, May, 1918.)—The standard value, g_0, now agreed on, is 980·665 c.g.s.; whereas the exact average value of g at latitude 45° in the United States is 980·621 as shown in the latest work of the Geodetic Survey. A formula can be deduced for g for any latitude assuming the earth to be a perfect ellipsoid of uniform density. Also a simple rational formula, called the "free air correction," can be deduced for the effect of elevation above sea-level. Here we assume that we are located in free air at a distance above sea-level without any intervening earth. But the problem at any place may be complicated by plateaus, mountains, and sea depressions, by different geologic strata, and so on. The problem is simplified by using the principle of isostatic adjustment. On this principle, if the earth were a perfect fluid, but composed of materials of different density, there would be a flow and adjustment of materials so as to give bulges on the earth's surface when density is below average and depressions where density is above average. The plan, then, is to use the isostatic adjustment principle to give a correction to the simple formula above mentioned. The results obtained are found to be a good approximation to facts and by applying at any place the anomaly an empirical value is found from contour lines drawn on the map. The well-known Bouguer formula is now found to be less satisfactory than the free-air formula.
P. E. S.

1144. *Nomenclature of the Unit of Absolute Pressure.* **C. F. Marvin.** (Monthly Weather Rev. 46. pp. 73–75, Feb., 1918.)—Two widely different units of pressure based upon the C.G.S. system have been adopted, each being termed the "bar." The unit now coming into general use in meteorology equals 10^6 dynes per $cm.^2$ while the alternative unit of 1 dyne per $cm.^2$ is used by chemists and physicists. The names "barad" or "barye" have been suggested for the latter unit but have not been accorded a favourable reception. A table is given in which the different pressures met with in scientific work are set out expressed according to the two systems, and it is pointed out that the meteorological unit is more convenient for general use than the physical or chemical unit. It is hoped that the confusion at present existing from the use of the same name *bar* for two widely different units may be removed by international agreement. J. S. Di.

1145. *Periodic Irrotational Waves of Finite Height.* **T. H. Havelock.** (Roy. Soc., Proc. 95. pp. 38–51, Sept. 2, 1918.)—A general method for numerical calculation is suggested, which includes waves of all possible heights, ranging from the highest wave down to the simple infinitesimal wave. The method consists of a simple and direct extension of Michell's analysis for the highest wave. L. H. W.

1146. *Variation of Velocity of Waves due to Motion of the Source.* **D. Alter.** (Lick Observat. Bull. 9. [No. 310], pp. 151–154, 1918.)—In a former paper on Finite Velocity of Gravitation as a Possible Factor in Stellar Evolution [see Abs. 480 (1918)], the following statement was made : "A velocity of propagation which depends on the velocity of the source need not necessarily demand an emission hypothesis. Certain results observed in the firing of big guns may be published later. Preliminary evidence tends to indicate that the velocity of sound waves is affected by the velocity of the source."

At the earlier time it was impossible to make a statement concerning a variation of the velocity of sound due to the velocity of the source. This, it is felt, can now be done with some definiteness. The velocity of a wave depends not only on the medium in which it moves, but also on the velocity of the source from which it emanates. The evidence, theoretical and experimental, now seems to the author fairly conclusive. The theoretical evidence is based on J. H. Poynting's treatment (Encyclopædia Britannica, vol. 25, p. 440) of the propagation of a longitudinal wave in an elastic medium, by introducing an external pressure X. Poynting gives the equation $X = (E - \rho_0 U^2) dy/dx$...(5), and writes as follows :—

"If then we apply a pressure X given by (5) at every point, and move the medium with any uniform velocity U, the disturbance remains fixed in space. Or if we now keep the undisturbed parts of the medium fixed, the disturbance travels on with the velocity U, if we apply the pressure X at every point of the disturbance. If the velocity U is so chosen that $E - \rho_0 U^2 = 0$, then $X = 0$, or the wave travels on through the action of the internal forces only, unchanged in form and with velocity $U = \surd(E/\rho)$... (6)." "If, however, we put on external forces of the required type X, it is obvious that any wave can be propagated with any velocity, and our investigation shows that when U has the value in (6) then, and only then, X is zero everywhere, and the wave will be propagated with that velocity when once set going."

From this point the present author feels that all that it is necessary to do is to show that such an external pressure exists. This pressure he attributes to the vibrations of a vibrating tongue when it is moving forward at speed U, so that its forward velocity of vibration is 2U greater than its backward velocity, at corresponding phases of the motion. These motions exist through equal intervals of time. The tongue, therefore, transmits to the neighbouring air particles a motion depending on its own. The author then quotes the whistling heard from shells coming directly towards him at about twice the normal velocity of sound. Of seven shots, the observers heard the whistling of four before the splash occurred of the shot into the water.

The paper concludes with a notice of certain astronomical theories and observations which are held to favour the author's views. E. H. B.

1147. *On the Apparent Form of the Dome of the Sky.* **H. Dember and M. Uibe.** (Ann. d. Physik, 55. 5. pp. 387–396, June 4, 1918.)—The sky does not appear to be in the form of a hemisphere, but seems depressed at the zenith by an amount which is greater by day than by night. Assuming that the apparent shape is part of a sphere, which assumption is subsequently shown to be justified, the amount of the depression can be determined by estimating by eye the middle point of the arc from zenith to horizon, and then measuring instrumentally the angular altitude of that point. The authors find that: (1) The clearness of the sky exercises a considerable influence upon its apparent height; (2) the sky appears to be higher in the sub-tropics (Island of Teneriffe) than in Germany; (3) on moonless and exceptionally clear nights the shape of the sky differs little from a hemisphere; (4) these phenomena are apparently due to optical conditions of the atmosphere which have not yet been determined. R. C.

1148. *The Drift of the "Endurance."* **J. M. Wordie.** (Geographical J. 51. No. 4, April, 1918. Nature, 101. pp. 487–488, Aug. 22, 1918. Abstract.)—This is a report on the oceanographic observations made by the *Endurance*, which carried the Weddell Sea contingent of the recent Shackleton expedition. The soundings show that a line of relatively deep water runs south from 74° to 76° S. to the Wilhelm Barrier. Off the Luitpold coast to the East, there is shallow water less than 100 fathoms deep, while in a westerly direction the edge of the continental shelf is marked by depths under 250 fathoms.

In high latitudes in the Weddell Sea, winter climate is characterised by the absence of low temperatures, minimum temperatures being scarcely lower than those observed in the S. Orkneys, some 500 miles to the north.

R. C.

LIGHT.

1149. *Spectroradiometric Investigation of the Transmission of Various Substances.* **W. W. Coblentz, W. B. Emerson,** and **M. B. Long.** (Bureau of Standards, Bull. 14. pp. 658–676 [Sci. Papers, No. 325], 1918.)—This paper gives the spectral transmission of various substances, especially coloured fluorite, light-filters, and coloured glasses. Some of the substances investigated provide a simple means for obtaining narrow spectral bands of radiant energy of high intensity and covering a wide range, without the employment of a spectroscope. By properly combining them it is possible, for example, to obtain a screen having narrow transmission bands at 0·38 μ, 0·5 μ, 0·55 μ, 0·7 μ, 0·8 μ, 1 μ, and 2·2 μ. The data on coloured glasses are useful in giving information as to their applicability for protecting the eyes from injurious radiations. A. W.

1150. *Absorption of Infra-red Radiation by Water-vapour.* **W. W. Sleator.** (Astrophys. J. 48. pp. 125–143, Sept., 1918.)—This paper is concerned particularly with absorption in the region of the spectrum between the wave-lengths 1·3 μ and 3 μ, and presents a detailed study of the absorption regions marked Ψ, Ω, and X on Langley's charts. To secure a high dispersion gratings were used, and the troublesome overlapping of the grating spectra was eliminated by the use of a supplementary prism. The dispersion thus obtained was higher than that used by Eva von Bahr with a prism spectrometer [Abs. 1858 (1914)]. Tables and diagrams of the absorption bands from 1·3 μ to 6 μ are given, and should be consulted by those interested. A. W.

1151. *Scattering of Light by Air Molecules.* **R. W. Wood.** (Phil. Mag. 36. pp. 272–273, Sept., 1918.)—In a recent paper [Abs. 835 (1918)] Strutt described experiments on the scattering of light by dust-free air. Wood, in 1902, carried out experiments practically identical as regards method and results with those of Strutt, but the results were found to be spurious. A spark was used as the source of light. It was found that if the spark was stopped and the tube thoroughly washed out with purified air, absolutely no trace of the cone of scattered light was visible on turning on the spark. In about ten seconds, however, a trace of the cone appeared, and after the spark had been in operation for a minute it was well developed. Interposition of a glass plate prevented the formation of the cone. This appeared to prove conclusively that the ultra-violet light caused a precipitation of something from the air, giving rise to a slight cloud. Using sulphuric acid instead of phosphorus pentoxide as a drying agent only made matters worse. Hence it is suggested that Strutt's experiments should be repeated before the scattering of light by air molecules can be considered to have been demonstrated. If, using sunlight and a glass lens, the cone of light cannot be seen with the eye, it would show that Strutt's results were due to a cloud resulting from the action of the ultra-violet rays on the air. A. W.

1152. *Formulation of the Principle of Huyghens.* **A. Anderson.** (Phil. Mag. 36. pp. 261–270, Sept., 1918.)—Mathematical.

1153. *Coloured Interference Bands and the Colours of Tempered Steel.* **A. Mallock.** (Roy. Soc., Proc. 94. pp. 561–566, Aug. 1, 1918.)—It has been generally assumed that the colours of tempering were instances of the ordinary interference colours of thin plates. If this be so, a reduction of the thickness of the film should change the colour. This was not found to occur, however: the intensity of the colour decreased as the film became thinner but its character remained the same. The colours of tempering are best seen by polarised light, and their intensity is greatest at the angle of max. polarisation. It would seem that temper colours are due to some form of selective opacity depending on damped molecular periods comparable with the wave period, rather than on a structure comparable with the wavelength. The colour effect due to the interference between the two series of lines superposed is considered. F. C. T.

1154. *Theory of Foucault's Test and the Radiation from the Edges of Diffracting Apertures.* **S. Banerji.** (Indian Assoc. for Cultivation of Science [35 pp.], 1917. Astrophys. J. 48. pp. 50–58, July, 1918.)—Rayleigh has recently given a treatment, on the principles of the wave theory, of the phenomena observed when an optical surface is examined by the "knife-edge" test due to Foucault [Phil. Mag., Feb., 1917]. He has shown how the luminosity of the boundaries which is observed when the bulk of the light is cut off may be accounted for as due to the diffraction of the rays reaching the focal plane, and he has also considered the effects produced by introducing optical retardations of a linear type over the surface of the aperture. In the present paper the author has extended Rayleigh's method of investigation to other cases of interest, particularly those in which the surface under test has a circular boundary and is illuminated by a point source of light, and an attempt has also been made to consider the effects observed when the retardations are of a non-linear type, *i.e.* when the foci of the pencils do not all lie in the plane of the knife-edge. A number of photographs are reproduced illustrating the emission of light by the edges of apertures with circular and with rectilinear boundaries. A. W.

1155. *Diffraction by Systems of Small Apertures or Opaque Particles.* **W. J. de Haas.** (K. Akad. Amsterdam, Proc. 20. 9 and 10. pp. 1278–1288, 1918.)—The diffraction image obtained with a glass plate on which lycopodium has been scattered appears to have a fibrous radial structure. This was investigated by v. Laue, who came to the conclusion that it could not be explained by classic optics. Experiments here described tend to the conclusion that the fibrous structure of the diffraction image can be accounted for satisfactorily by the ordinary diffraction theory. Opaque screens were used in which one or more circular apertures of the same diam. were pierced; and as the number of apertures was increased, the change from the ordinary diffraction image for a single circular aperture to the fibrous appearance observed by v. Laue could be easily followed. Mathematical treatment is given in support of the author's views. A. W.

1156. *Reflecting Power of Tungsten and Stellite.* **W. W. Coblentz** and **W. B. Emerson.** (Bureau of Standards, Bull. 14. pp. 307–316 [Sci. Papers, No. 308], 1917.)—In a previous paper [Abs. 1148 (1917)] it was shown that tungsten, in common with all the pure metals thus far investigated, has a low reflecting power in the visible spectrum, which rises quite abruptly to a high value beyond 2 μ in the infra-red. Further investigation has revealed certain peculiarities. The present paper gives the results of a critical examination of the reflecting power of tungsten in the region of the spectrum from 0·5 to 6·0 μ. The reflecting power of tungsten in the form of plane, highly polished mirrors was determined by comparison with silver and also by a new method in which use is made of a total reflection prism. The results obtained are based upon an examination of three samples of pure tungsten and one sample of unknown purity. All the samples show a marked depression in the reflectivity curve at 0·8 μ. A similar indentation occurs at 1·3 μ in the reflectivity of the pure metal, but is absent in the sample of impure tungsten. The reflecting-power curve of pure tungsten rises abruptly from 50 % at 0·6 μ to 90 % at 2 μ, beyond which the reflectivity increases gradually to about 96 % at 6 μ. The bands of selective reflection at 0·8 μ and 1·3 μ render tungsten conspicuous as being the only pure metal thus far investigated which has bands of selective reflection in the infra-red. The minimum of reflection at 0·8 μ causes a perceptible protuberance in the emission spectrum of an incandescent tungsten filament. The reflecting power of stellite rises gradually from 65 % at 0·6 μ to 88 % at 9 μ. A. W.

1157. *Electrical Resolution and Broadening of Helium Lines.* **T. R. Merton.** (Roy. Soc., Proc. 95. pp. 30–38, Sept. 2, 1918.)—Stark's suggestion that the broadening of lines in the condensed spark discharge is intimately connected with the resolution of lines into components by the electric field, has been shown to be in qualitative agreement with the broadening which occurs in the lines of the Balmer series of hydrogen [Abs. 678 (1916)]. Further, in the case of H_α, it has been shown [Abs. 1037 (1916)] that a quantitative analysis of its structure is in complete harmony with Stark's observations of the electrical resolution of the line, on the assumption that the broadening is due to the effect of the electric fields of neighbouring charged portions on the radiating atom. It was also found that certain effects in helium and lithium were in qualitative agreement with the hypothesis. Takamine and Yoshida have recently [Abs. 840 (1918)] provided material for a closer and more rigorous inquiry into the connection between the two effects. Using Lo Surdo's method they have shown that the effect is not merely a splitting of the lines into components, the separation of which increases with the electric field, but that in some cases an isolated component appears at a certain strength of field and is further resolved or displaced as the field is increased. In the present paper details are given of the broadening and structure of a number of helium lines, and the results confirm the view that the broadening of helium lines by condensed spark discharges is in close agreement with the electrical resolution of the lines. The isolated components in the electrical resolution, which have been recorded by Brunetti and by Takamine and Yoshida, have also been found in the broadened lines. An explanation is offered of the relative degree of broadening of lines of the "arc" and "spark" type, on the supposition that the latter act as a kind of safety-valve to the former when the intensity of excitation becomes very great, *i.e.* that the tendency of the atom to emit its characteristic "arc" radiation rapidly decreases when the degree of excitation exceeds a certain value. It is suggested that the isolated components are not a direct product of the electrical resolution, but are in reality an extension of the helium spectrum. Two of these lines may perhaps be represented as lines of combination series. A. W.

1158. *Variation with Temperature of the Electric Furnace Spectra of Ca, Sr, Ba, and Mg.* **A. S. King.** (Astron. J. 48. pp. 18–34, July, 1918.)—The methods used in this investigation for observing the temperatures at which spectral lines appear, and the rate at which they increase with rising temperature, were, on the whole, the same as those employed for the examination of other spectra [Abs. 1415 (1914)]. The electric furnace was operated *in vacuo*, except for occasional tests under other conditions, and the spectra were photographed in the first and second orders of a 15-ft. concave grating. The chief interest of the present paper lies in the photographs reproduced and in the tabular statement of results for the lines of Ca, Sr, Ba, and Mg appearing at each of three stages of temperature. The lines are classified according to the temperature at which they appear and their rate of change with increase of temperature. Special note is made of connection with series relations, of change of characteristic features of the furnace spectrum with the wave-length, and of differences of structure in furnace lines as compared with those of the arc. The differences of structure in the case of Ba, have led to the measurement of a number of ultra-violet lines not given in tables of arc wave-lengths. A. W.

1159. *Flame and Furnace Spectra of Iron.* **G. A. Hemsalech.** (Phil. Mag. 36. pp. 209–230, Sept., 1918.)—An account is given of experiments carried out with the electric tube-resistance furnaces. The observations, while in many respects tending to corroborate those of King [Abs. 1817 (1913)], lead to conclusions differing materially from those advanced by King. The results show that the spectra of iron as given by an electric tube furnace at atmospheric pressure and up to a temperature of about 2400° C. are caused by the action of heat on a chemical compound of the metal, and not on the free metal itself. Hence these spectra are not of purely thermal origin. An iron spectrum has been observed at a temperature as low as 1500° C., the spectrum being the same as that given by an air flame burning in coal-gas. The spectra emitted by iron compounds in flames are identical with those given by the furnace at corresponding temperatures up to about 2400° C. From this and from other considerations it has been concluded that the mode of excitation must be the same in the two cases, namely, chemical dissociation of an iron compound by the action of heat. The character of the spectrum is independent of the nature of the iron compound which is acted upon by the thermal forces in either flame or furnace. Thus, chlorides, oxides, etc., always give the same kind of spectrum in either of these sources at the same temperature. Such spectra due to thermo-chemical excitation differ completely from the spectra given by the same compounds in the explosion region of the air–coal-gas flame, where the emission is due to chemical excitation at a comparatively low temperature. A new group of class I lines and possessing characteristics similar to those of group γ, has been found, the head of the group being at λ5270. The Al lines λλ3944 and 3962 have been observed at a temperature as low as 1500° C. This latter fact is remarkable in view of the fact that all attempts to obtain them in the air–coal-gas flame have so far proved unsuccessful. It may be that the carbide of Al is more readily dissociated than those compounds of this element which are generally employed in feeding flames. Tables of results are given and photographs are reproduced. A. W.

1160. *Red and Infra-red Spectra of Iron, Cobalt, and Nickel Arcs.* **W. F. Meggers** and **C. C. Kiess.** (Bureau of Standards, Bull. 14. pp. 637–651, [Sci. Papers, No. 324], 1918.)—The arc spectra of iron, cobalt, and nickel were photographed in the red and infra-red regions on plates stained with pinacyanol and dicyanin. A large concave grating was used, and exposures up to 10 hours' duration registered many lines with wave-lengths greater than 10,000 Å.U., or 1 μ. In the arc spectrum of iron, 298 lines were measured between the limits λ6750 and λ10689; 606 lines were measured between λ5508 and λ11628 in the arc spectrum of Co; and 290 lines between λ5504 and 10843 in the arc spectrum of Ni. As far as possible, impurities were eliminated and the lines assigned to their proper element. The results demonstrate that an invisible long-wave interval as large as the entire visible spectrum is accessible to photography with dicyanin-stained plates. The incompleteness of spectroscopic data for these longer light-waves invites extensive application of this method of spectrum photography. The lines λλ7771, 7774, 7775 were given by Meggers in his table of copper lines. They have now been observed in the spectra of Fe, Ni, Si and Cu. The mean values of their wave-lengths derived from all the measurements taken, including those not yet published, are 7771·928, 7774·138, and 7775·433 Å.U. These lines constitute the well-known triplet which, according to Runge and Paschen, belongs to the principal triplet series of oxygen. The chief interest here lies in the fact that they appear among the arc lines of various metals. They have been observed by St. John and by Meggers as absorption lines in the solar spectrum. In this connection, attention is called to the line λ8446·42 which appears in the iron arc spectrum. This corresponds with a strong line in the spectrum of oxygen as observed by Runge and Paschen. It also exists as an absorption line in the solar spectrum, and it has been found in the spectrum of the copper arc in air. A. W.

1161. *Ionisation with Reference to Light Emission in the Positive Layer.* **O. Hardtke.** (Ann. d. Physik, 56. 5. pp. 383–387, Aug. 22, 1918.)—Positive ions, whether atomions or moleculions containing more than one atom, are, according to Stark [Abs. 637 (1917)] the carriers for definite spectra. Thus the series spectrum of hydrogen is associated with the H^+ ion, the band or many-lined spectrum of hydrogen belonging to the H_2^+ moleculion. The red argon spectrum belongs to the Ar^+ atomion, while the positive nitrogen bands are associated with the N_2^+ moleculion. Taking these facts into account with the ionisation phenomena in the positive layer, it appears that in a mixture of gases with different ionisation potentials the various spectra corresponding to the different ions will be emitted in the positive layer at different positions which will be in the same order as the ionisation potentials. Investigation along these lines has been carried out with mercury, nitrogen, and argon. The ionisation potential for mercury vapour is variously given as 5–5·8 volts, that of argon, according to Franck and Hertz, being 12 volts. Mayer gives the ionisation potential of nitrogen as 11·8 volts, while Franck and Hertz obtained the value 7·5 volts. The results of the present research show that the ionisation potential of the diatomic nitrogen molecule certainly lies between the values for mercury and argon, *i.e.* between 5 and 12 volts. From the curves reproduced Mayer's result would appear to be too great. A. W.

1162. *Absorption of X-rays.* **E. A. Owen.** (Roy. Soc., Proc. 94. pp. 510–524, Aug. 1, 1918.)—The author summarises as follows:—(1) The absorption coefficients of a number of substances for a radiation of wave-length 0·586 $\times 10^{-8}$ cm. (the α-line of Pd) have been determined, and the values obtained confirm those of Bragg and Pierce [Abs. 75 (1915)] in the case of elements commonly used. (2 The atomic fluorescent absorption coefficient is proportional approximately to the fourth power of the atomic number of the absorber. (3) The following relation exists between the atomic fluorescent absorption coefficient, atomic number of the absorber, and the wave-length of the radiation absorbed : $F_a = CN^4\lambda^3$, where C is a constant over certain ranges, but changes abruptly at critical points. This relation is independent of the scattering coefficient ; it deals only with the loss of energy of X-radiation by the production of corpuscular radiations and the fluorescent X-radiations that accompany them. (4) Calculations based on the above general relation show that the molecular total absorption coefficients of different substances observed by Aurén [Abs. 961 (1917)] with radiation of wave-length 0·35 × 10^{-8} cm. may be deduced very approximately from the atomic total absorption coefficients obtained for different elements with radiation of wave-length 0·586 × 10^{-8} cm., if the coefficient of scattering be assumed to have a constant value of 0·2 for all elements from hydrogen to bromine, for both these radiations. A. B. W.

1163. *Critical Absorption and Characteristic Emission at X-ray Frequencies.* **W. Duane** and **K. F. Hu.** (Phys. Rev. 11. pp. 489–491, June, 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—It is well known that a marked change in the absorption of X-rays by one of the chemical elements occurs in the neighbourhood of the emission lines of the K-series of that element. Blake and Duane [Abs. 291 (1918)] have measured the critical absorption wave-lengths (λ_a) for most of the elements from bromine to cerium, both inclusive, estimating the error in measurement at about 0·1 %. These wave-lengths differ from the shortest emission wave-lengths in the K-series of the elements that have been measured by considerably more than 0·1 %. To determine, if possible, whether there is a real difference between the critical absorption wave-length (λ_a) and the wave-length (λ_γ) of the γ-line in the emission spectrum, the authors have undertaken to re-measure both these quantities, using as nearly as possible the same experimental conditions in the two cases. As a result of very careful measurement, it has been demonstrated in the cases of iodine and of rhodium that the critical absorption wave-length and the critical emission wave-length are exactly the same. For rhodium $(\lambda_a) = (\lambda_\gamma) = 0·5330 \times 10^{-8}$; for iodine $\lambda = 0·3737 \times 10^{-8}$ cm. A. B. W.

1164. *Maximum Emission Velocity of Photo-electrons from Metals at X-ray Frequencies.* **K. F. Hu.** (Phys. Rev. 11. pp. 505–507, June, 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—A preliminary account of an attempt to obtain qualitative and quantitative data regarding this question. It is shown that the secondary electrons play an important part in the emission of the characteristic X-radiation. The relation $h\nu = Ve \tfrac{1}{2}mv^2$ was verified by measurements of the limiting edge of the continuous spectrum.

The quantitative investigation of the max. velocity and the velocity distribution was prematurely interrupted by an accident to the X-ray bulb.

A. B. W.

1165. *Relation between the "K" X-ray Series and the Atomic Numbers of the Chemical Elements.* **W. Duane** and **K. F. Hu.** (Phys. Rev. 11. pp. 488–489, June, 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—Moseley's classical experiments show that the square roots of the frequencies, ν, of corresponding lines in characteristic X-radiation are almost, but not quite, linear functions of the atomic numbers. Recent experiments show that the curves representing $\sqrt{\nu}$ as functions of N bend slightly upward. It is interesting to inquire whether some other characteristic of the X-radiation might not be an *exact* linear function of the atomic number.

It is now shown that the *critical* velocity of electrons required to produce characteristic radiation is a linear function of N—that is, *the critical velocity increases by equal amounts from one element to the next.* A. B. W.

1166. *Relation between the General X-radiation and the Atomic Number o the Target.* **W. Duane and T. Shimizu.** (Phys. Rev. 11. pp. 491–492, June, 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—Examining the metals Fe (26), Co (27), Ni (28), and Cu (29), it has been found that, without exception, the intensity of the X-radiation increases as the atomic number (not the atomic weight) of the target increases. The intensity of the radiation is approximately proportional to the atomic number, but the range of atomic numbers is too small to test this point accurately. A. B. W.

1167. *New Secondary Radiation of Positive Rays.* **M. Wolfke.** (Phil. Mag. 36. p. 270, Sept., 1918.)—In a recent publication [Abs. 68 (1918)] the author expressed his belief that the penetrating radiation then observed was the characteristic radiation of tin and lead, this conclusion being based on certain intensity-differences on photographs. Further experiments have not, however, confirmed this supposition, but have led to the discovery of a source of error in the earlier researches. Careful investigation of the nature of the secondary radiation shows that it is excited by positive ions. From an approximate valuation the coefficient of absorption of the new radiation is estimated to be of the order of that of the characteristic K-radiation of Al. [See also Abs. 947, 948 (1918).] A. B. W.

RADIO-ACTIVITY.

1168. *Radium.* **R. B. Moore.** (Am. Inst. Mining Eng., Bull. No. 140. pp. 1165–1182, Aug., 1918.)—The subject is dealt with from a commercial standpoint and is treated in the following sections:—(1) History, (2) Radio-activity, and disintegration series, (3) Radium ore deposits, (4) Metallurgical treatment, (5) Methods of ore concentration, (6) Future supply of ore, (7) Uses of radium, (8) Mesothorium as a substitute for radium. A. B. W.

1169. *Radio-activity of Some Canadian Mineral Springs.* **J. Satterley** and **R. T. Elworthy.** (Canad. Dept. of Mines, Bull. No. 16. Part I. [55 pp.] 1917. Review by F. Soddy in Nature, 100. pp. 6–7, March 7, 1918.)—These investigators have reported on the radio-activity of 47 mineral springs and 23 deep-well waters of the Dominion, the chemical character and composition of which are later to be dealt with in Part II. The examination was undertaken in view of the belief that the therapeutic value of mineral waters may be ascribed to their radio-activity. A. B. W.

HEAT.

1170. *Direct Adiabatic Calorimetry at High Temperatures.* **A. Perrier.** (Archives des Sciences, 46. pp. 42–44, July, 1918. Paper read before the Soc. Suisse de Physique.)—A preliminary paper pointing out the advantages of the adiabatic method of calorimetry for high-temperature work. The author suggests the possibility of adapting for this purpose the electrical method of heat supply first employed by Gaede in researches at low temperatures; also that the walls of the enclosure could be heated up at the same rate as the test specimen so as to eliminate corrections for heat-transfer by radiation, etc. It is pointed out that the great experimental difficulty will be to obtain equality of temperature in the space containing the calorimeter when an electric furnace is employed. This difficulty could be overcome to some extent by making the container of a material possessing a high thermal conductivity.

Since no experiments have been tried all details are lacking. E. G.

1171. *Propagation of Flame through Tubes of Small Diameter.* **W. Payman and R. V. Wheeler.** (Chem. Soc., J., Trans. 113. pp. 656–666, Aug., 1918.)—Part of a research on miners' safety-lamps conducted for the Home Office. The uniform movement of flame, further studied first of all, is developed only when the mixture is contained in a tube ignited near the open end, the other end being closed. As the diameter of such a tube decreases the cooling effect of the tube walls increases, and the limits of inflammability are narrowed. Thus in a horizontal tube, 3 m. long, 4·5 mm. in diam., only a mixture of 9·95 % methane (really firedamp, from a blower, with 2 % nitrogen as only impurity) would propagate the flame; in a tube of 5·6 mm. the limits were 8·25 and 10·6 % of methane, and the slowest rate of speed at which the travelling flame would be maintained was 35 cm. per sec. The higher the thermal conductivity of the tube the narrower the limits of inflammability. In a tube (second series of experiments), open at both ends, the flame advances at increasing speed towards the other end (except in the case of a limit-mixture when the speed is uniform); having travelled a certain distance the flame vibrates to and fro until extinguished during rapid vibration. This distance is greater for long wide tubes than for others and is the smaller the nearer the methane percentage approaches that of the fastest flame speed, which is 9·5 or 10 % methane in air. Thus a narrow tube, which would stop a flame at 10 % methane, may allow a flame of 7 % to pass through, though the former flame has the greater speed, because the vibrations are less violent. These experiments were made with glass tubes, 100 cm. long, or brass tubes connecting wider glass tubes, the length being gradually shortened; precaution to prevent passage of the flame is particularly necessary with low percentages of methane. In miners' lamps the air may reach the flame from below (conditions like those mentioned), or more frequently from above, when the upper portion of the lamp is charged with explosive mixture and ignition takes place as in the case of a closed tube ignited near the closed end. This case was studied with a glass vessel, 12 cm. long, 2 cm. diam., closed at one end, to the open end of which different brass tubes were fitted. Brass tubes less than 2 cm. long, up to 8 mm. diam., did not propagate the explosion to the explosive mixture outside, although a tongue of flame might project. But when, in other explosion apparatus of greater lengths, the speed of the projection of the flame was raised, the protection afforded by short tubes failed. In miners' lamps, however, the conditions depending on these dimensions are not exceeded. The results agree with Beyling's experiments of 1906 on flame-proof electric apparatus; the cooling effect of the expansion of the gases in the passages prevented any ignition of explosive mixtures outside the apparatus. H. B.

1172. *Density, Compressibility, and Atomic Mass of Argon.* **A. Leduc.** (Comptes Rendus, 167. pp. 70–71, July 8, 1918.)—The gas as supplied to the author by Claude was contaminated with about 5 % of impurities, the major part of which consisted of nitrogen and oxygen, these latter approaching nearest to argon in their critical constants. Details of the purification scheme adopted are given. The gas was considered pure when a further operation no longer modified its density. The limiting density was found to be 1·3787, and the difference between this and the value of 1·379 as obtained by Ramsay and Travers is ascribed, not so much to the volume corrections of the containing vessel, as to the small number of their experiments. The compressibility has been examined between 1 atmo. and 5 atmos. and the average coefficient of deviation between these limits from Mariotte's law at 14° C. has been found equal to $10{\cdot}2 \times 10^{-6}$. The curves and formulæ which embrace the author's experimental results upon normal gases would give only $8{\cdot}5 \times 10^{-6}$ for this coefficient using Crommelin's critical constants of $-122{\cdot}4$ and 48 atmos. If these data be almost exact, argon cannot be placed in the normal series, and in order to apply the formulæ which allow of other numerical data being computed it is necessary to replace the observed critical pressure by 40 atmos. The molecular volume of argon relative to the perfect gas under normal conditions is 0·9990, *i.e.* scarcely different from that of oxygen (0·9992). The molecular mass, which in this case is identical with the atomic mass, is therefore 39·91. The second decimal place, however, cannot be guaranteed.

H. H. Ho.

1173. *Influence of the Finite Volume of Molecules on the Equation of State.* **M. N. Shaha** and **S. N. Basu.** (Phil. Mag. 36. pp. 199–202, Aug., 1918.)—The departure of the actual behaviour of gases from the ideal state defined by $p = \mathrm{NK}\theta/v$ is due to: (1) the finiteness of the volume of the molecules, (2) the influence of the forces of cohesion amongst the molecules. This was first expressed by van der Waals. In subsequent modifications of van der Waals' equation of state, the changes proposed all relate to the influence of the cohesive forces, the finiteness of molecular volumes being generally left untouched. The experimental results, however, do not agree with theoretical predictions of a and b regarded as absolute constants, and, accordingly, these have been considered as functions of volume and temperature.

The present authors now examine whether the influence of finite molecular volumes is properly represented by the term b, and they conclude that such is not the case. A more detailed investigation is promised with respect to the variability of the volume of molecules with temperature. Meanwhile the factor $e^{-a/(\mathrm{VK}\theta v)}$ has been introduced into the expression for p as a provisional measure. H. H. Ho.

1174. *On the Saturated Vapour Tensions of Octo-atomic Bodies.* **E. Ariès.** (Comptes Rendus, 167. pp. 118–122, July 15, 1918.)—This paper is an extension to octo-bodies of work on the saturated vapour tensions of liquids. The substances examined were methyl formate, ethyl bromide, ethyl chloride, acetic acid, and ethane. The two latter bodies do not afford satisfactory results, and in the case of acetic acid this was to be expected in view of its liability to polymerisation. Of the other three bodies, methyl formate is the only one which affords sufficient experimental data for the author's purpose. This has been used for the determination of the formulæ constants. The exponent n was found to be 9/10, and the function Γ becomes

$$1 + [(1-\tau)(0{\cdot}88-\tau)]/[(1-\tau)^2 + 0{\cdot}8]$$

rendering

$$\Pi = \tau^{2+9/10}(Z/x), \text{ and } x = [1 + (1-\tau)(0{\cdot}88-\tau)/(1-\tau)^2 + 0{\cdot}8]\tau^{1+9/10}.$$

A table is given showing the very satisfactory agreement between the calculated and experimental results. Regnault's somewhat limited data for ethyl bromide are found to agree with those calculated on the formulæ. The various experimental data for ethyl chloride are discussed at some length, accompanied by three tables of results based on Regnault and Berthoud's observations. Discrepancies are explained on the ground of uncertainty with respect to the value of the critical constants. Too much stress, however, is not laid on this method, as one for the indirect evaluation of the critical constants, but the author claims that the vaporisation tensions of methyl formate, ethyl bromide, and ethyl chloride are in accord with one and the same relation, and in harmony with the law of corresponding states. [*Errata*. (*Ibid.* p. 220, July 29, 1918.)] H. H. Ho.

1175. *On the Saturated Vapour Tensions of Pentatomic Bodies.* **E. Ariès.** (Comptes Rendus, 166. pp. 935–939, June 10, 1918.)—The author has found experimental data in the "Recueil de Constantes Physiques," which enable him to apply his vapour-tension formula to the 6 pentatomic bodies; stannic chloride, methyl fluoride, chloroform, methane, methyl chloride, and carbon tetrachloride. The last three substances do not afford results in accordance with the law of corresponding states, neither do these agree among themselves. Stannic chloride is the only body upon which experiments are recorded throughout the whole of the desired range. These were carried out by Young, and allow of 6/7 being assigned as the value of the exponent n. The function Γ which equals unity when the reduced temperature is $\tau = 0{\cdot}84$, has the form $\Gamma = 1 + [(1-\tau)(0{\cdot}84-\tau)]/[1{\cdot}8(1-\tau)^2 + 0{\cdot}9$. The numerator of the second term is seen to be the same as for monatomic and tetratomic bodies, but the denominator, which previously had the form $A\tau^2 + B$, must be modified as above, so as to decrease as τ increases. The formulæ now become:

$$\Pi - \tau^{2+6/7}/(Z/x), \quad x = [1 + (1-\tau)(0{\cdot}84-\tau)\tau/1{\cdot}8(1-\tau)^2 + 0{\cdot}9]^{1+6/7}.$$

The data for methyl fluoride, which are due to Collie, are much less comprehensive, but give results in agreement with the above formulæ, save for those at the lowest temperature observed, namely —5° C. The present author indicates association as the probable cause of this anomaly. With respect to chloroform, Regnault's data cease at 160° C., which temperature is about 100 deg. below the critical temperature; recent work by Kuenen and Robson having fixed 262·9° C. for the temperature and 53·8 atmos. for the critical pressure. The application of the formulæ to these data does not in consequence afford satisfactory results. The author believes a change of state to be the explanation of the cause of the divergence. By the method already employed for mercury, the critical constants for chloroform are found theoretically to be 247° C. and 45·26 atmos. The author therefore concludes that stannic chloride, methyl fluoride, and chloroform exhibit saturated vapour tensions which satisfy the law of corresponding states. Tables of results for these three bodies are given. H. H. Ho.

1176. *On the Characteristic Equation of Fluids.* **P. Weiss.** (Comptes Rendus, 167. pp. 232–235, Aug. 5, 1918.)—The method of discussion adopted for the study of magnetic isothermals is here applied to the compression isothermals of fluids. The lines of equal magnetisation are replaced by isochors, *i.e.* lines of equal volume. The controversy as to their rectilinear or curvilinear character was closed by an empirical rule given independently by Young and Keesom. A revision suggested by the magnetic phenomena has caused the present author to find that in this case of fluid compression isothermals the facts are represented to a striking degree by straight lines which bend sharply. Four diagrams are included. The first represents the isochors of air according to Witkowski's experiments, and these are characterised by a very well-defined angle. The second are the isochors for ethylene deduced from Amagat's isothermals; here the angles are smaller but well defined. The third gives the isochors for liquid ether, while the fourth depicts Young's experiments on isopentane. H. H. Ho.

1177. *On the Saturated Vapour Tensions of Bodies with High Atomicity.* **E. Ariès.** (Comptes Rendus, 167. pp. 267-270, Aug. 12, 1918.)—By an investigation of the vapour tensions of a large number of liquids whose compositions varied from 1 to 8 atoms, the author has shown that the exponent n of the temperature T in the second term of the equation of state has a value $\frac{1}{2}$ for monatomic substances which increases slowly with the number of atoms and attains the value 9/10 for bodies built up of 8 atoms [see Abs. 1174 (1918)]. Except for monatomic liquids, the exponents adopted are represented by the formula $n = (\mu + 1)/(\mu + 2)$, in which μ is the degree of atomicity, and although the author attaches no importance to this particular empirical expression, yet whatever may be the mode of variation of n it is such as to have a limit of unity for an infinite number of atoms. The author has, in consequence, taken $n = 1$ for bodies of high atomicity, thereby making his vapour-tension formulæ: $\Pi = \tau^3 Z/x$, $x = \tau^2 \Gamma$. The function Γ will, therefore, according to the law of corresponding states, give the degree of atomicity of the body. The above formulæ have now been applied to the four saturated paraffin hydrocarbons, pentane, hexane, heptane, and octane, whose vapour tensions have been determined over an extended thermometric range as far as the critical temperature by Young. The following expressions for Γ have been adopted, namely:

$$1 + (1 - \tau)/(4{\cdot}6\tau^2 + 0{\cdot}4) \text{ for pentane,}$$
$$1 + [(1 - \tau)(0{\cdot}90 - \tau)]/[1{\cdot}5(1 - \tau)^2 + 0{\cdot}525] \text{ for hexane,}$$
$$1 + [(1 - \tau)(0{\cdot}84 - \tau)]/[1{\cdot}17(1 - \tau)^2 + 0{\cdot}63] \text{ for heptane,}$$
$$\text{and } 1 + [(1 - \tau)(0{\cdot}80 - \tau)]/[2{\cdot}25(1 - \tau)^2 + 0{\cdot}65] \text{ for octane.}$$

The reduced temperature which makes the function Γ unity is seen to increase as the degree of atomicity decreases. Pentane appears to be an exception, which would indicate the atomicity not being sufficiently elevated to admit of n being made unity. The conclusion is drawn that n may be made unity for bodies containing not less than 23 atoms. Tables of data are given in the paper for the four bodies, and these show very satisfactory agreement with the author's theoretical propositions. H. H. Ho.

1178. *Thermodynamics based entirely upon Carnot's Principle. A Second Absolute Temperature.* **C. Raveau.** (Comptes Rendus, 167. pp. 20–28, July 1, 1918.)—The author first deals with thermodynamics based solely on Carnot's principle. Classical thermodynamics only utilises a combination of two of the fundamental properties of Carnot's cycles, and defines only one absolute temperature based on the two quantities of heat involved in the performance of a cycle. These two quantities are in a ratio to the work involved which only depends on the temperatures of the sources, and it is possible to define a second absolute temperature which remains independent of the first so long as only Carnot's principle is invoked. The introduction of the equivalence principle therefore causes one absolute function of the temperature to disappear. The same occurs with regard to the mechanical equivalent of heat, which, when measured upon an infinitesimal reversible cycle of the second order, is only a function of the temperature. The formulæ derived without recourse to the equivalence principle, only differ from the classical relations by the substitution for E, of a temperature function which itself depends on the two absolute temperatures. Absolute equivalence, independent of temperature, is true for all bodies if for one; and to admit the existence of a perfect gas is to admit equivalence without restriction. In Part II of the paper, the second absolute temperature receives definition; it is found to be evaluated by the area of a Carnot's cycle described by a thermometric body, chosen once for all; one of the isotherms and the two adiabatics being always the same. For a perfect gas the two absolute temperatures are identical. Part III of the paper deals with differential properties. If $d\theta$ be the difference of the second absolute temperatures of two points infinitely near, and d^2w be the area of Carnot's cycle which admits these two points as opposite apices, then the quotient $d^2w/d\theta$ is a total differential, and the three equal quantities

$$1/l\,.\,\partial p/\partial\theta, \quad -1/p\cdot\partial v/p/d\theta, \quad 1/(C_\theta - c_\theta)\,.\,\partial p/\partial\theta\,.\,\partial v/\partial\theta$$

are a like integral factor of $d\phi$. In Part IV the latter quotients, and their products when multiplied by $d\theta$, are shown to be absolute functions of the temperature.

Entropy is thus expressed independently of any quantity of heat.

Reference is made at the conclusion to Larmer's paper "On the Nature of Heat as Directly Deducible from the Postulate of Carnot" [Abs. 695 (1918)].

H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1179. *Molecular Instability caused by Magnetostriction.* **D. Hurmuzescu.** (Rev. Gén. d'Él. 4. pp. 211–214, Aug. 17, 1918.)—Certain experiments on the e.m.f. of a cell, of which one electrode was an iron plate subjected to different magnetic fields, pointed to the orientation of the particles as being an important factor in the case. For the examination of the effects of this orientation the cell method was abandoned in favour of that of magnetostriction. The test body was a long ovoid of magnetic material set, with its long axis vertical, within a coil capable of producing a field of 3000 c.g.s. The change of length was noted by means of an interference-band method, and the results with regard to change of length agree in general with those already known. The author records the observation of a certain molecular instability in the specimen when there is max. change of length. This was observed only in iron, and was the more distinct the greater the permeability of the iron. The phenomenon is explained by the use of Ewing's theory.

G. E. A.

1180. *On Electromagnetic Induction and Relative Motion.* II. **S. J. Barnett.** (Phys. Rev. 12. pp. 95–114, Aug., 1918.)—A more complete account of the work dealt with in Abs. 547 (1918).

1181. *Specific Inductive Capacity of Metals.* **F. Sanford.** (Phys. Rev. 12. pp. 130–135, Aug., 1918.)—It has long been a question whether the properties of specific inductive capacity and electrical conductivity can coexist in the same substance. Maxwell's notion that induction is produced by a displacement of the bound electricity in the ether, whether free or between the atoms of a dielectric substance, would make it seem impossible that induction could take place through a body in which electric charges are free to move. Also, since the dielectric constant of a substance was defined as the reciprocal of an elastic modulus, viz., as the ratio of the displacement of an electric charge to the e.m.f. which produces the displacement, and since the smallest e.m.f. may produce a continuous electric displacement in a conductor, it seems to follow from the definition that the dielectric constant of a conductor is infinite. However, a closer consideration may show us that this conclusion is not necessary. Thus, one of our modern theories of metallic conductivity assumes that there are in metals both free and bound electrons, and that the free electrons alone are concerned in current conductivity. If this be true, it is not, *a priori*, impossible that an electric displacement in the Maxwellian sense may be produced in these bound electrons by the e.m.f. which produces the current. Since we are compelled to look upon induction as something different from a displacement of bound electrical charges, there is no longer any ground for the assumption that a conductor may not possess the property of specific inductive capacity. Shirley Hyatt showed that induction does, in fact, take place freely through a metallic conductor until the inducing charge is neutralised, so far as its inducing power is concerned, by the bound charge which it induces upon the conductor. The work of Coehn and his colleagues seems to show a very definite relation between specific inductive capacity and contact electrification, so that in the case of all non-metallic substances, solid, liquid, or gaseous, substances of higher specific inductive capacities acquire positive charges from contact with substances of lower specific inductive capacities. Since metallic substances may be charged by contact with other metallic or non-metallic substances regardless of their conductivity, it would seem that Coehn's law should apply to them also, and that if metals have the high specific inductive capacities attributed to them they should take positive charges from all other substances. It would seem that if metals take their places distributed throughout the contact series with the non-metallic substances it is natural to conclude that their dielectric constants are also distributed in a similar manner throughout the dielectric series. It was for the purpose of finding if this were the case, and not for determining the contact of frictional series with a high degree of accuracy, that these experiments were undertaken. Two methods were employed for testing the charges produced upon the metals by friction or contact. In one of these methods the conducting substances were mounted upon insulating handles, usually of ebonite, and the non-conducting substances were usually held in metallic forceps or tongs to avoid giving them charges by contact with the hand. The two were rubbed together, or merely placed in contact and separated, and their charges were tested by a Wilson tilted electroscope, the plate of which was connected to 100 dry cells. This gave the character of the charges and enabled one to tell whether the substances tested were close together or far apart in the frictional series. In the other method the metals to be tested were used in the form of rods. They were suspended from an insulating support and connected to one side of a 4-mfd. paper condenser, the other side of which was joined to earth. After the rod had been rubbed or brushed with the substance with which the metal was being compared, the condenser was disconnected from the metal and discharged to earth through a ballistic galvanometer. It was hoped that this second method might give comparable quantitative values, but such was not the case except in a very rough manner. From the table given it is seen that the metals take their places in the contact or frictional series with dielectric substances just as the latter do with each other. The natural inference to be drawn from this fact is that the places taken by the metals in this series are determined by their dielectric constants, just as are the places of the non-metallic substances. This being true, we may state the following laws: (1) The specific inductive capacities of metals are of the same order of magnitude as are those of non-metallic substances. (2) The more electro-positive a metal is in the contact series the higher is its specific inductive capacity.

The results obtained by other workers on the specific inductive capacity of water appear to be in agreement with those now obtained. A. E. G.

1182. *Ions produced by bubbling Air through Alcohol.* **J. A. McClelland** and **P. J. Nolan.** In a previous paper [Abs. 805 (1916)] the nature of the ions produced by bubbling air through mercury was examined. The present paper gives results for alcohol, also further results for mercury, and compares both with the ionisation obtained by spraying distilled water. It appears that the ions obtained by bubbling undried air through mercury also occur when distilled water is sprayed. The ions found when dried air is bubbled through mercury form another set. Both sets were found in the experiments with alcohol, in which case the air was not dried; neither was it saturated with water-vapour. A further examination is in progress of the difference between the ions found with water and with alcohol. Experiments are also being carried out on the mobilities of the ions formed by phosphorus. Details will be published later. A. W.

1183. *The Formation of Negatively Electrified Raindrops.* **F. Sanford.** (Phys. Rev. 11. pp. 445–448, June, 1918.)—If a large and a small conducting sphere after being placed in contact and charged positively are separated, and a very small sphere is placed directly between the two in contact with the smaller, it will obtain by induction a negative charge. This fact, which has long been known, is used by the author to explain the presence in the atmosphere of small negatively electrified water-drops though the normal charge on drops is positive. When a large drop breaks up owing to its motion through the air it has been found that it first divides into two globules of unequal size which remain for an instant connected by a cylindrical neck of water of small diameter. This neck then separates from the larger of the two globules and immediately after itself breaks up into minute droplets. If the original drop is positively electrified the conditions of the laboratory experiment described above are thus fulfilled and the negative charge on the minute droplets is explained. J. S. Di.

DISCHARGE AND OSCILLATIONS.

1184. *The Electric Conductivity of Salt Vapours.* **G. C. Schmidt.** (Ann. d. Physik, 56. 5. pp. 341–362, Aug. 22, 1918.)—The earlier methods employed by Garrett and the results he obtained with the vapours of certain salts are criticised. A new method of finding the velocity of ions from this source is described, and as the result of the experiments carried out it is concluded that even at very high temperature, if the surface remains constant, the conductivity of salt vapours is independent of the time. The very pronounced increase of the conductivity, which is so noticeable at the beginning of the heating, is explained by the fact that, under the condition of the experiment, the vapour only very gradually enters the space in which the conductivity is measured. The decrease which ultimately takes place in the conductivity is explained by the fact that the salt cakes so that its surface, and therefore its rate of producing vapour, diminishes; consequently the vapour density and ionisation decrease also. In spite of several attempts the author has not succeeded in obtaining satisfactory results when measuring the current strength. Values are obtained for the velocities of the ions in which the order of magnitude is in agreement with those obtained by Harms with the oxidation of phosphorus and those of McClelland in flame gases measured at distances far removed from the flame. In all these cases it is to be noted that indifferent molecules are invested with the ions. It is further stated that the velocity of the ions increases with the temperature and is a function of the "life" of the ion: the longer the "life" the smaller the velocity.
A. E. G.

1185. *Polarisation Measurements at Wire Kathodes in separately Ionised Gases.* **C. A. Skinner.** (Phys. Rev. 10. pp. 136–142, Aug., 1918.)—The results of an investigation of the polarisation at plane kathodes in separately ionised hydrogen and similar results from plane kathodes in oxygen, and preliminary measurements with wire kathodes in the same gas, have been reported previously [see Abs. 1004, 1005 (1917).] The present article is a report of the completed investigation of wire kathodes in separately ionised oxygen and hydrogen. With polarisation potentials ranging between about 10 and 80 volts, plane kathodes in the highly ionised negative glow of hydrogen give the following relation between the magnitudes involved: $V_b = g(j/n)^2$, where V_b is the polarisation p.d. and j the current density at the kathode, n the number density of the positive ions just outside the polarisation region—assumed from the experimental results to be nearly proportional to the ionising current—and g a constant depending on the kind of metal used. Comparison of plates and wires in separately ionised oxygen and also of wire kathodes in separately ionised hydrogen are made. Accepting the conclusion arrived at as the result of these experiments, viz., that the current to a given length of kathode is practically proportional to the cube root of its radius, it follows that the current density at the kathode is inversely proportional to the two-thirds power of the radius. For wires, then, the given equation takes the form $V_b = g'r^{4/3}(j/n)^2$ for values of V_b well above those at which the temperature velocity of the ions entering the polarisation region produces an appreciable effect. It is to be noted, however, that this does not necessarily invalidate the applicability of the theory by which the equation was deduced. For, in the theory, the value of j is at the entrance to the polarisation region instead of at the kathode, though with plates the two are equal. If the extent of the polarisation region is finite, the above variation with wires of different diameters should be expected from the theory of reflection. For the current density at the entrance to the polarisation region is supposed to be expressed by the equation, irrespective of the form of the electrode. A. E. G.

1186. *Simplified Theory of the Kathode-fall in Gases with Application to Plates and Wires.* **C. A. Skinner.** (Phys. Rev. 12. pp. 148–157, Aug., 1918.)—Measurements show the kathode-fall to be made up of two distinct though interdependent parts: (*a*) the p.d. between the negative glow and a point in the gas near the kathode; and (*b*) a polarisation p.d. between this point and the kathode arising from a very pronounced accumulation of positive ions there. With the smaller current densities (*a*) is usually somewhat larger than (*b*). With increasing currents (*a*) usually decreases and (*b*) always increases, soon becoming much the larger of the two magnitudes.

The polarisation p.d. has been the subject of special investigation during the last two years [see preceding Abs.]. It is conceived to arise from a reflection of the discharging ions from the kathode, and appears to be proportional to the potential gradient per mean free path of the positive ions just before they enter the polarisation region. The factor of proportionality varies distinctly with different metals, but scarcely appreciably with the gases used —hydrogen, nitrogen, oxygen. The fall in the gas between the negative glow and the polarisation region requires a more complicated explanation. It is shown that an extremely small electron current, conceived to be liberated from the kathode under the intense bombardment of the discharging positive ions, may account for the ionisation between the kathode and negative glow. Since one-half the current in the negative glow is carried by positive ions, and the rate of production of ions at any point is proportional to the total rate of ionisation between that point and the kathode, it follows that at one ionising interval from the negative glow toward the kathode, the positive ions carry three-fourths of the current; at two ionising intervals, seven-eighths, and so on. It is conjectured that the actual conditions may be effectually represented by simply assuming a localised source of ions either in the negative glow or somewhat nearer the kathode. With this as a basis the resulting potentials between the effectual source and the polarisation region at the kathode are calculated for both plane and cylindrical kathodes. The theory is experimentally tested with Al kathodes in hydrogen. With a plate kathode the effectual source lies somewhat nearer the kathode than the point of minimum gradient in the negative glow. Otherwise the theoretical curves fit the observations for different currents, and various currents agree in furnishing the same value for the mobility of the positive ions. This mobility is, however, very large when compared with that calculated from measurements made at atmospheric pressure. With wire kathodes the agreement between the theory and observation is practically perfect, the point of minimum gradient being also that of the localised source of ions. A series of observations with a relatively thick wire was made with special care. The different currents used agreed in furnishing practically the same value for the mobility of the positive ions as had already been obtained with a plane kathode. An increased mobility of the positive ions with the strong fields used here is to be expected, but the excessive magnitude obtained requires independent corroboration before this method of determining the mobility can be accepted as reliable. If the value is correct, then it appears likely that we have to do with atomic ions rather than molecular ions. This view for the negative ions has already been suggested to account for the observed rate of absorption of the gas at the anode. The closeness with which the simple theory of localised ionisation fits the results obtained with both plane and cylindrical kathodes is strong evidence of an excessive degree of ionisation in the negative glow as compared with that in the space toward the kathode. The results seem to indicate a condition of ionisation existing here similar to that exhibited by α-rays—namely, increasing ionisation with decreasing velocity. Since the polarisation p.d. at the kathode and the field-strength in the gas are about twice as large with the wire as with the plate, the effectual source should therefore, as was actually observed, be nearer the point of minimum gradient in the case of the wire. It is suggested that the polarisation region at the kathode marked in extent by the kathode glow—about 0·2 mm. thick. Accepting this, the polarisation p.d. is found to be proportional to the potential gradient per mean free path of the positive ions at their entrance to this region.

H. A. Wilson, denying the existence of kathode polarisation, concludes that the consequent bombardment of the kathodes by the positive ions is insufficient to furnish the necessary electron emission from the kathode to maintain the current. He has instead applied Townsend's theory of ionisation by the positive ions to account for its maintenance. Since Wilson published his article, results from a separate kathode placed in the negative glow, and similar observations by Tate and Foote with a separate anode seem to establish beyond reasonable doubt the existence in general of electrode polarisation. From Cheney's investigation it is to be concluded that a much larger electron current than that deemed necessary in the present case, is emitted by a kathode when the bombarding ions have sufficient velocity. In a recent article indirect evidence is given that an Al kathode in hydrogen and oxygen emits an appreciable electron current when the polarisation p.d. is equal to or even less than that found with the "normal" kathode-fall. Furthermore, while Townsend himself obviously prefers the hypothesis that the positive ions produce the necessary ionisation in the gas, he shows that it would be impossible to determine from his results whether the hypothesis of ionisation by positive ions, or that of the liberation of electrons from the kathode is the better. With the accumulating evidence of electrode polarisation, the latter hypothesis is greatly strengthened and the former correspondingly weakened by the probable existence of a disturbing kathode polarisation in Townsend's experiments. If such were the case his supposedly constant field-strength with increasing distance between the electrodes was in reality an increasing polarisation p.d. at the kathode at the expense of the rest of the field. The result would be to increase the electron current from his kathode as the distance between his electrodes increased, introducing a corresponding error in the value of both of his ionisation constants. This impression strengthens when it is realised that Townsend carried out his measurements at glow-current pressures and under practically glow-current potentials. A. E. G.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1187. *Note on Electrical Conduction in Metals at Low Temperatures.* **F. B. Silsbee.** (Bureau of Standards, Bull. 14. pp. 301–306 [Sci. Papers, No. 307], 1917.)—The passage from electrical super-conductivity to normal conductivity of metals at low temperatures may be attained with a critical current density or by the application of a critical magnetic field. The author regards these two means as interdependent. In a previous paper [Abs. 155 (1917)] the case of a wire conveying a current was treated and the magnetic field resulting was such as to give rise to a central superconducting core with an outer resisting layer. This condition is unstable. The present note contains a more complete solution of the problem by Langevin. According to this there are three regions: (1) a superconducting core where the field (H) due to the current is less than the critical magnetic field (H_c), (2) an intermediate layer where $H = H_c$, and (3) an outer layer where $H > H_c$. If, in passing from the superconducting to the normal state by the application of a magnetic field the resistance increases k times, then when the current is increased to the critical value the resistance will suddenly increase to $k/2$ times. With further increase of current the resistance continues to increase, at first rapidly and then slowly as it approaches asymptotically to k times its original value. The results of this theory are then compared with the few data available and appear to the author to be in satisfactory agreement. L. L.

1188. *Verification of the Thomson Theory of the Thermoelectric Circuit and a Method of measuring the Thomson-effect.* **G. Borelius.** (Ann. d. Physik, 56. 5. pp. 388–400, Aug. 22, 1918.)—The author has used a modified form of an apparatus previously described to measure the Peltier-effect [Abs. 807 (1917)] in order to verify the equation $de/dT = \pi/\tau$ for the thermoelectric circuit. Seven metals and alloys were investigated and the experimental results confirm the theory. To prove experimentally that $\sigma_1 - \sigma_2 = T d^2E/dT^2$ the author has devised a direct method to measure the Thomson-effect. He investigates theoretically the case of a wire conveying a current, in which lateral heat losses are prevented and obtains an equation for the temperature distribution along the wire. If the ends of the wire are fixed to two calorimeters it is shown that $\sigma = \frac{3}{4}[(t_2 - t_1)(W + w/l)(1 + 2w/l)]/\Theta s$, where $2l$ is the length of the wire, t_1, t_2, are the end temperatures, and Θ is the temperature of the mid-point. w is the heat conducted per sec. along the wire for a temperature gradient of 1 deg. C. per cm., W a similar quantity for the material of the calorimeters, and S the current through the wire. Six different wires were employed and the experimental results are in agreement with the Thomson theory. L. L.

1189. *Null Ballistic Method for comparing Capacities.* **P. Thomas.** (Frank. Inst., J. 186. pp. 377–381, Sept., 1918.)—It having become necessary to measure capacities of the order 10^{-9} to 10^{-11} farad, the author devised a method which is simpler than the standard methods and involves fewer corrections, while being applicable at frequencies lower than those usually required by other methods. Instead of measuring capacity by means of a train of impulses through a ballistic galvanometer, which involves accurate measurement of the speed of the commutator and the charging voltage, a train of impulses from one condenser is balanced by a second train from a different condenser passing through the galvanometer in the opposite direction. If C_1 is the condenser to be measured and C_2 a known condenser, usually a standard subdivided 1-mfd., R_1 and R_2 standard rheostats which can be adjusted till there is no permanent deflection of the spot of light, then $C_1/C_2 = R_2/R_1$. The apparatus is so arranged that the galvanometer can either receive the charge or the discharge impulses, any difference in value being due to absorption or leakage. V. C.

1190. *Thermal and Electrical Conductivities of Nickel Steels.* **K. Honda.** (Tôhoku Univ., Sci. Reports, 7. pp. 59–66, July, 1918. 19th Report of the Alloys Research Inst.)—To test the Wiedemann-Franz law the author has measured the electrical and thermal conductivities (k,λ) of a number of Ni steels, the method employed being that described in former papers [Abs. 102, 405 (1918)]. The specimens were prepared from a low-carbon steel and ordinary commercial Ni and were examined for uniform structural distribution. Their conductivities were determined in two states: (1) cooled from 900° C. to room temperature ($k_1\lambda_1$); (2) heated from — 190° C. to room

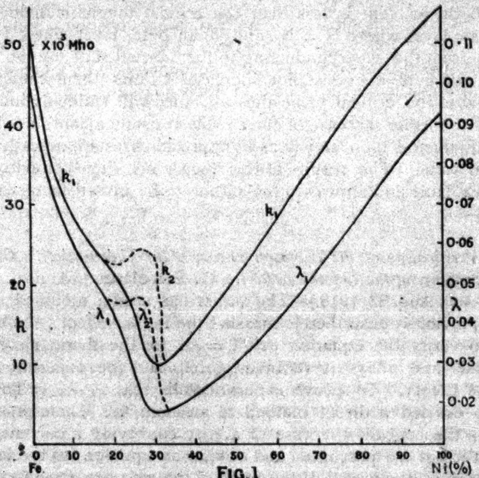

FIG. 1

temperature ($k_2\lambda_2$). The composition and results are given in tables in the paper. Fig. 1 shows the variation of k and λ with percentage composition. The minimum value for both k and λ occurs at 30 % Ni for the alloys cooled from 900° C. and not at 35 %, at which Weiss assumes the existence of a compound Fe_2Ni. The ratio λ/k is approximately constant. Below 31 % Ni, the mean value is $1{\cdot}98 \times 10^{-6}$, and above 31 % $1{\cdot}68 \times 10^{-6}$. Magnetisation curves were also obtained for the same specimens. Fig. 2 is the magnetisation-concentration curve in a field of 1300 gauss for the two states of the alloys. L. L.

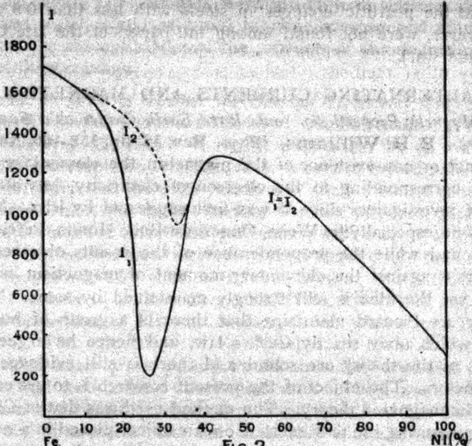

FIG. 2

1191. *Magnetic Transformation of Carbon Steels.* **G. Rümelin** and **R. Maire.** (Ferrum, 12. pp. 141–154, July, 1915. Rev. de Mét. 15. p. 241, July–Aug., 1918. Abstract.)—Experiments were made with 13 pure carbon steels, none of which contained more than 0·329 % other constituents altogether. The specimens were supplied in rods of 10 or 20 mm. length by Krupp and tested by the method of Lewkonja, as modified by Honda, in an electric furnace (porcelain tubes, 61 cm. long, 20 mm. diam., wound with nichrome); to prevent oxidation the specimens were wrapped in asbestos paper impregnated with sodium silicate, and a vacuum of $\frac{1}{3}$ mm. of mercury was maintained in the furnace. The carbon percentage of the specimens ranged from 0·11 up to 1·54. In the steels containing up to 0·43 % C the magnetism undergoes a sudden and perfectly reversible change in weak fields on very slow heating at the point A_2, and the cooling and heating curves coincide; at temperatures above A_2 the ferromagnetism is feeble and disappears completely at A_3, the change being continuous and reversible; the position of A_3 depends on the carbon percentage, an increase in carbon lowering the temperature of A_3. For pure iron A_2 would be 768°. When the carbon percentage lies between 0·4 and 0·8, the temperature hysteresis increases, whilst the transformation temperature is lowered to A*c* or A*r*; the temperature interval necessary for the transformation can be derived from the separation and the solution of the β iron according to the phase-diagram, the author believing with P. Weiss (contrary to Honda) that the β state is not a phase, but represents a change in the properties of a phase, such change progressing continuously with temperature. Eutectic and hypereutectic steels undergo an irreversible change which stops at the same point Ac_1 and Ar_1 for all the steels examined. Allusion is made in the authors' summary to notes on the pearlitic changes in steels with less than 0·8 % C; these notes, however, were not found among the papers of the late G. Rümelin (killed in the war). H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1192. *Magnetic Properties of some Rare Earth Oxides as a Function of the Temperature.* **E. H. Williams.** (Phys. Rev. 12. pp. 158–166, Aug., 1918.)—The existence or non-existence of the magneton, the elementary quantity of magnetism corresponding to the electron of electricity, has attracted the attention of investigators since it was first suggested by Ritz. Much work has been done, especially by Weiss, Onnes, du Bois, Honda, Perrier, Piccard, and Terry, and while the preponderance of the results obtained by these investigators is against the elementary moment of magnetism as suggested by Weiss, yet the idea is still strongly maintained by some. Within the last three years Piccard maintains that there is a group of bodies (paramagnetic) which obey strictly Curie's law, and hence he argues that the foundations of the theory are sound and there is still evidence in favour of the magneton. The object of the present research is to get evidence for or against the magneton theory. The method used was that of Curie, which consists in measuring the pull exerted on an object placed in a non-uniform magnetic field. According to this method the magnetic susceptibility per unit mass is given by the expression $X = [1/(MH_y \cdot \partial H_y \partial/x)](C\phi/l)$, providing the force is measured by means of the twist of a suspension. In this expression M is the mass of the sample, H_y the field at right angles to the direction of motion of the sample, dH_y/dx the variation of this field along the direction of motion, C the couple necessary to twist the suspension through one radian, ϕ the angle of twist in radians, and l the lever arm from the line of suspension to the sample. The oxides of seven of the rare earths, namely erbium (Er_2O_3), dysprosium (Dy_2O_3), lanthanum (La_2O_3), gadolinium (Gd_2O_3), samarium (Sa_2O_3), neodymium (Nd_2O_3), and yttrium (Yt_2O_3), were investigated. Before using any of the oxides, they were heated to a temperature of about 1000° C. in a Pt crucible in order to decompose any carbonate which may have formed and to drive off all moisture. The samples under investigation were contained in a silica capsule which was fitted to one arm of the torsion balance. The balance, with thermo-couple and empty capsule in place, was first calibrated for fields due to currents from 1·5 to 5 amps. and for temperatures from 25° C. to 800° C. The mass susceptibilities for the oxides of erbium, dysprosium, gadolinium, samarium, neodymium, lanthanum, and yttrium have been measured for the above temperature range and all found to be paramagnetic with the exception of lanthanum, which was slightly diamagnetic. In those cases where the susceptibility varies with the temperature Curie's law is not found to hold, but the results follow quite closely a modification of this law, namely, $X(T + \theta) = \text{constant}$. It follows that in so far as Curie's law is essential to the existence or determination of the magneton the results obtained are unfavourable. The magnetic susceptibility does not vary with the field-strength. The results are explainable either by the theory worked out by Kunz or by the zero-point energy theory of Oosterhuis. A. E. G.

1193. *Magnetic Susceptibility of Mixtures of Liquids.* **A. W. Smith** and **A. W. Smith.** (Am. Chem. Soc., J. 40. pp. 1218–1224, Aug., 1918.)—The authors have studied the magnetic susceptibilities of a few series of mixtures of liquids in order to see how nearly the observed susceptibility agrees with that calculated from the concentration of its components by an application of the additive law. The mixtures investigated were acetone and water, acetic acid and water, acetic acid and benzene, acetone and ethyl alcohol. It is found that the susceptibilities of the mixtures of the above liquids obey closely the additive relation. A. F.

1194. *On the Problem of whether the Diurnal Terrestrial Magnetic Variation on the Earth's Surface possesses a Potential.* **A. Schmidt.** (Phys. Zeits. 19. pp. 349–355, Aug. 15, 1918.)—A recent publication by A. van Vleuten [Abs. 569 (1918)] attempts to establish, after a careful investigation of available observation data, that the daily variation of the horizontal component of territorial magnetism at the earth's surface does not possess a potential. In view of the importance of this result (particularly with respect to air electrification) the present author now attempts a rigid inquiry into the grounds for the above conclusion. The work of Balfour Stewart and Schuster on this subject is first reviewed [see Roy. Soc., Phil. Trans. 180. (1889), and Abs. 1158 (1908)], followed by that of Fritsche, Steiner, G. W. Walker, van Bemmelen, and Chapman. The calculations of van Vleuten are found to represent an essential advance, however, on previous work since they are based on strictly homogeneous and well-defined observation data. These are next carefully examined from a different mathematical standpoint, and the conclusion is drawn that the observation data are in accord with the assumption of a potential. Tables are included in the paper. H. H. Ho.

1195. *The Magnetic Storm of Dec. 16–17, 1917, as recorded at Kew and Eskdalemuir Observatories.* **C. Chree.** (Roy. Soc., Proc. 94. pp. 525–547, Aug. 1, 1918.)—During the magnetic storm of Aug. 22, 1916 [Abs. 414 (1917)], the disturbances at these two observatories were closely similar in type. In the present case the changes differed notably in type. In the Kew declination (D) and horizontal force (H) curves, a prominent feature was a succession of oscillations with periods of about 20 mins. It was the hope of identifying these with corresponding oscillations at Eskdalemuir that suggested the present investigation.

The Eskdalemuir curves contained some exceedingly large rapid oscillations, practically unrepresented at Kew. These must presumably have arisen from some source of disturbance which was either purely local, or was situated very much nearer to Eskdalemuir than to Kew.

Element.	Rises.			Falls.			Rises and Falls.		
	Aggregates.		Mean rate.	Aggregates.		Mean rate.	Aggregates,		Mean rate.
	Duration.	Movement.		Duration.	Movement.		Duration.	Movement.	
	mins.	γ.	γ/min.	mins.	γ.	γ/min.	mins.	γ.	γ/min.
Kew H	188	1034	5·5	175	1217	7·0	363	2251	6·2
Kew D	146	529	3·6	158	576	3·6	304	1105	8·6
Eskdalemuir N ...	183	2214	12·1	196	2430	12·4	379	4644	12·3
Eskdalemuir W ...	178	2069	11·6	156	2163	13·9	334	4232	12·7
Eskdalemuir V ...	137	775	5·7	138	985	7·1	275	1760	6·4

(Unit $1\gamma \equiv 1 \times 10^{-5}$ C.G.S.)

The table gives particulars of the aggregates of the rises and falls. But for the loss of trace, the time aggregate for V at Eskdalemuir would have been considerably larger. While the time aggregates for the different elements are not identical, we may fairly conclude that during the most active part of the storm changes in N and W at Eskdalemuir were roughly twice as rapid as changes in H, and 3½ times as rapid as changes in D at Kew [Abs. 306 (1918)]. The V changes at Eskdalemuir and the H changes at Kew had very similar mean rates, but the fastest V changes at Eskdalemuir were decidedly faster than the fastest H rates at Kew. The V traces were, however, of a very different type from the others, oscillations of short period being much less in evidence. Considering that the ranges of the diurnal inequalities in N and W at Eskdalemuir in December are only about 15γ and 20γ respectively, it is a little startling to find that during six hours of one particular "day," the mean rates of change per min. in these elements were quite 12γ. The contributions to the aggregates of changes from the other 18 hours of the 24 would have been considerable, and the mean rate of change in N and W for the whole 24 hours could hardly have been less than 4γ per min. E. O. W.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1196. *A Radiotherapeutic Unit of Quantity.* **H. Bordier.** (Comptes Rendus, 167. pp. 214–216, July 29, 1918.)—The units that have been proposed up to the present are based upon a cutaneous reaction and therefore upon a variable element. It is now attempted to establish a unit based upon a physico-chemical reaction. A solution of iodoform in chloroform, 2 parts in 100, is used for the purpose. The rays acting upon this solution set free the iodine, and the weight of this liberated iodine serves as a measure of the quantity of X-rays acting upon the solution: the weight of iodine liberated is determined by a comparison of the resultant tint of the solution radiated. A dozen solutions of iodine in chloroform are made for comparison; these solutions range in strength from 0·3088 mgm. to 2 mgm. of iodine per cm.^3. They are placed in receptacles of the same diam. as those containing the solution of iodoform which is submitted to the X-rays, and when viewed they are seen through a transparent yellow surface of the same tint as the iodoform solution before radiation. It is shown that the iodine liberated is in proportion to the time of radiation, and that after a radiation made under conditions identical with those which are most frequent in practical radio-therapeutics the weight of iodine liberated in the unit volume of iodoform solution is about 0·4 mgm. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1197. *A New Table of the Periodic System.* **I. W. D. Hackh.** (Am. Chem. Soc., J. 40. pp. 1023–1026, July, 1918. Am. J. Sci. 46. pp. 481–501, Sept., 1918.)—A new arrangement of the periodic system is shown in the accompanying table. The groups of elements are preserved and a clear-cut classification of the elements into non-metals, noble gases, light metals, heavy metals, is substantiated. In the upper half of the table are the

THE PERIODIC SYSTEM OF THE ELEMENTS.

(Atomic numbers, symbols, groups, periods.)

	4	5A	6A	7A		0		1A	2A	3A	4	
Vb	82 Pb	83 Bi	84 Po	85		86 Nt		87	88 Ra	89 Ac	90 Th	VI
IVb	50 Sn	51 Sb	52 Te	53 I		54 Xe		55 Cs	56 Ba	57 La	58 Ce	Va
IIIb	32 Ge	33 As	34 Se	35 Br		36 Kr		37 Rb	38 Sr	39 Y	40 Zr	IVa
IIb	14 Si	15 P	16 S	17 Cl		18 Ar		19 K	20 Ca	21 Sc	22 Ti	IIIa
Ib	6 C	7 N	8 O	9 F		10 Ne		11 Na	12 Mg	13 Al	14 Si	IIa
				1 H		2 He		3 Li	4 Be	5 B	6 C	Ia
III′	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	III
IV′	40 Zr	41 Cb	42 Mo	43	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	IV′

V″	58 Ce	59 Pr	60 Nd	61	62 Sa	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Ad	70 Cp	71 Yb	72 Lu	V″

V′	72 Lu	73 Ta	74 W	75	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	V′
VI	90 Th	91 Bv	92 U									
	4	5B	6B	7B		8		1B	2B	3B	4	

elements possessing high electro-potential, simple spectra, colourless ions. In the lower half are the elements with low electro-potential, complex spectra, coloured ions, and which tend to form complex double salts. In the upper half of the table, the similarity among the elements is in the vertical direction; in the lower half, in the horizontal direction. In order to place the isotopes of the radio-active elements it will be necessary to place the top row from lead to thorium at the bottom of the table, extending the row on both sides so as to include the elements with atomic numbers 81 to 92. Under this line the system of the radio-active elements can be placed, which then will form a kind of appendix to the main table. A. F.

1198. *Observations on the Rare Earths.* VII. *The Separation of Holmium.* **L. F. Yntema** and **B. S. Hopkins**. (Am. Chem. Soc., J. 40. pp. 1163–1167, Aug., 1918.)—The purification of holmium is difficult because of its scarcity and close resemblance to dysprosium, on the one hand, and yttrium on the other. By means of 4 series of fractional hydrolyses of the phthalates the holmium content of a holmium-yttrium mixture was increased from 12 % to 25·4 %. One series of fractional precipitations with sodium nitrite increased the holmium content 25 % in material poor in holmium. The colour of the oxide of the least basic fraction of a series containing holmium, dysprosium, praseodymium, neodymium, yttrium, and terbium, indicated that the terbium was about all removed and the absorption spectrum failed to reveal traces of either neodymium or praseodymium. The colour of the oxide and absorption spectrum of the most basic fraction showed a concentration of terbium, praseodymium, and neodymium. Dysprosium cannot be removed by this method. The fractional precipitation with sodium nitrite is considered the better of the two methods. A. F.

1199. *Studies in Liquid Crystals.* **T. C. Chaudhari.** (Chem. News, 117. pp. 269–270, Aug. 16, 1918.)—From a study of the properties of a number of liquid crystalline substances, the author concludes that there exists a general relation among the members of a homologous series of compounds in respect of the ranges of temperature through which their liquid crystalline phase is stable, and the relation may be represented by an approximately definite quantity. The liquid crystalline phase appears in these compounds because their molecules cannot readily adjust themselves to the perfectly disbanded condition as in an isotropic liquid when heated, and similarly they cannot suddenly orient themselves in space-lattices when the molten substance is allowed to cool. In the view of the author it is not possible to assign any definite relation between the constitution of compounds and their capacity for producing liquid crystals. According to the author, the formation of liquid crystals is a general property of malleable organic solids. A. F.

1200. *Hydrodynamics of Slimy-crystalline Liquids.* **O. Lehmann.** (Ann. d. Physik, 56. 5. pp. 321–340, Aug. 22, 1918.)—Further investigations dealing with the substances previously described by the author [Abs. 473 (1916)]. L. H. W.

1201. *Comparative Tests of American Chemical Glassware.* **P. H. Walker** and **F. W. Smither.** (Bureau of Standards, Technol. Papers, No. 107. [23 pp.], Washington, 1918.)—The table on p. 479 gives a general summary of the resistance to the various solutions and to mechanical and heat shock of the wares tested. In this table the numerical exponents indicate the minor differences in resistance, the lowest number being the most resistant.

Ware.	Resistance to—						
	Water.	Mineral Acids.	Carbonated Alkalies.	Caustic Alkalies.	Ammonia and Ammonium Salts.	Heat Shock.	Mechanical Shock.
Kavalier	Poor	Good	Poor	Good^{2}	Good^{2}	Poor	Poor
M. E. G. Co.	Good^{3}	Good	Good^{1}	Good^{1}	Good	Poor	Poor
Pyrex	Good^{2}	Good	Good^{3}	Fair	Good	Good^{1}	Good^{a}
Jena	Good^{4}	Good	Good^{2}	Fair	Good	Good^{3}	Fair
Nonsol	Good^{3}	Good	Good^{1}	Fair	Good	Good^{2}	Fair
Fry	Good^{4}	Good	Good^{2}	Fair	Good	Poor	Good
Libbey	Good^{1}	Good	Good^{3}	Fair	Good	Good^{2}	Good

[a] Far superior to any of the other wares.

These results indicate that all the American-made wares tested are superior to Kavalier, and equal or superior to Jena ware for general chemical laboratory use. L. H. W.

1202. *Rate of Solution of Atmospheric Nitrogen and Oxygen by Water.* **W. E. Adeney** and **H. G. Becker.** (Roy. Dublin Soc., Proc. 15. pp. 385–404, Aug., 1918.)—The authors have studied the rate of re-aeration of water by passing air-bubbles up a tube filled with water. In the case of the three waters used, the rate of re-aeration was found to be the same when based on the percentage of saturation, and this rate of re-aeration was found to be in accordance with the expression $dw/dt = 30{\cdot}8 - 0{\cdot}308w$, where w is the weight of gas per cm.^{3} in the upper layer of water. This gives the rate of re-aeration in percentages of saturation per min. for an exposed area of 56 cm.^{2}. A. F.

1203. *The Theory of Gel Structure.* **W. A. Osborne.** (Roy. Soc. Victoria, Proc. 30. 2. pp. 153–158, March, 1918.)—The author has tested the behaviour of gels when subjected to the Struve-Baumstark reaction.

A 10 % sodium stearate gel when placed in ether begins to discharge liquid at once. If the fluid is drained off until no more forms, it will be found that the liquid phase of the soap gel has been replaced wholly by ether. The discharged fluid, however, has some of the solid phase in solution, and exposed to the air and so allowed to lose its dissolved ether, will revert to a moderately firm jelly. The gel thus formed can again be treated with ether, and again a liquid phase will be discharged. The behaviour indicates that the liquid phase of the soap gel is held by capillarity in the open meshwork of the solid phase. If, however, a 5 % gelatine gel is submitted to ether immersion, no fluid or only an exceedingly small amount is extruded. A 2 % gelatine will show the Struve-Baumstark phenomenon clearly. In the 5 % gel the fluid may be assumed not merely to be held by capillarity, but to exist in solid solution in the substance of the framework, whereas in the 2% gel the water-logged lattice holds by capillarity a fluid with a small amount of solid matter in solution. The author believes that the Struve-Baumstark phenomenon can be employed to distinguish those gels where the liquid phase is held, in part at least, by capillarity from those in which the fluid is held, through imbibition, by the hydrophile lattice of the solid phase.

A. F.

1204. *The Formation of Graphite in the Iron-Carbon Series of Alloys.* **J. E. Hurst.** (Engineering, 106. pp. 217–218, Aug. 30, 1918.)—A consideration of the explanations and diagrams suggested of the precipitation of graphite and formation of "kish" in high-carbon iron alloys. It is believed that at 1350° C. the following reaction occurs: $3Fe_2C \rightleftarrows 2Fe_3C + C$. The primary formation of Fe_3C is due to under-cooling, and at temperatures above 700° C. the carbon is slowly transformed into iron and graphite. The Upton diagram is believed to contain a certain element of truth. F. C. T.

1205. *The Calculation of Electro-chemical Normal Potentials.* **K. F. Herzfeld.** (Ann. d. Physik, 56. 2. pp. 133–160, July 12, 1918.)—A mathematical paper. On the assumption that the entropy constant of the dissolved ion is equal to that of the corresponding atom, the author calculates the normal potential for solid and gaseous elements. The calculated numbers show deviations from the measured values, which are the same for elements of the same ionic mobility. These deviations are attributed to the formation of complexes between the ions and water. Formulæ for the solubility of salts can also be given. In open cells only the positive ions are in equilibrium; for the electrons, equilibrium is established only very slowly, whereby the cell becomes approximately reversible. The author has also calculated the single potential, the contact potential, and the number of electrons in metals. The Helmholtz equation is not accurately applicable to single potentials.

A. F.

1206. *Application of Rapidly Rotating Metallic Reductors in the Estimation of Vanadic Acid.* **F. A. Gooch** and **W. Scott.** (Am. J. Sci. 46. pp. 427–436, Aug., 1918.)—It is shown that whilst vanadic acid may be quantitatively reduced within a reasonable time (30 mins.), in the presence of dilute sulphuric acid, by the action on the boiling solution of massive silver of considerable area, the reduction may be made very rapid by using rapidly rotating anodes of silver or copper in the electrolytic cell, or by using a rapidly rotating zinc cylinder as the reducer, over-reduction being corrected by the addition of silver sulphate to the solution. The reduced solution is titrated with standard potassium permanganate, and thus the amount of vanadic acid originally present is estimated. T. S. P.